Annals of Clinical and Analytical Medicine
Original Research

The role and importance of dynamic thyroid scintigraphy in clinical practice

Feray Aras
Department of Nuclear Medicine, Faculty of Medicine, Celal Bayar University, Manisa, Turkey

Abstract

Aim: In this study, we aimed to determine the nodule activity in thyroid scintigraphy in patients with thyroid nodules, as well as to determine the contribution of dynamic radionuclide thyroid Scintigraphy (RTS) in distinguishing between benign and malignant nodules.

Material and Methods: A total of 48 patients (30 women, 18 men) with hypo- and/or hyperactive thyroid nodules on thyroid scintigraphy larger than 1 cm were included in the study. Dynamic imaging was achieved in the thyroid region of the patients under a gamma camera and with an intravenous injection of 185 Mβq Tc99mpertechnetate. Retention rate (RR) was calculated using these curves and static anterior image counts. RR was found by drawing a total of 75 nodules of 48 patients. Power Doppler ultrasonography (PDUS) was performed on each patient at the same time and central peripheral resistive index (SRI) and peripheral resistive index (PRI) were measured. Nodule vascularization pattern was classified in PDUS.

Results: The mean age of the patients was 54.12 ± 13.41 years. While 40 patients had a fine needle aspiration biopsy (FNAB), 8 patients did not have an FNAB. Of the 64 nodules in 40 patients who underwent FNAB, 20 were identified as non-diagnostic, 38 as benign cytology (BC), and 6 as malignant cytology (MC). In the time activity curve obtained from RTA, it was determined that the probability of malignancy was high in nodules that were hyper-vascular and showed rapid clearance. While the average RR of nodules in BC was 0.41±0.70, it was calculated as 0.43±0.23 in MC. The average central RI in nodules in BC was 0.39±0.12, while in MC it was 0.30±0.63. The average peripheral RI value was calculated as 0.60±0.45 in BC and 0.62±0.29 in MC. Although our number of malignant cytology nodules was quite low, there was a statistically significant positive correlation between the malignant cytology RR value and the malignant cytology peripheral RI value ($p = 0.003$, $r = 0.043$). There was a significant positive correlation between the BC central RI value and the BC RR value ($p = 0.012$, $r = 0.054$).

Discussion: We think that dynamic RTS, which is a method that will increase the sensitivity of classical thyroid scintigraphy, support the necessity of FNAB, and will not bring additional radiation dose or difficulty to the patient, can be used routinely and has diagnostic value in the benign-malignant discrimination of thyroid nodules.

Keywords

Thyroid Nodules, Radionuclide Thyroid Scintigraphy, Power Doppler Ultrasonography

DOI: 10.4328/ACAM.21983 Received: 2023-09-18 Accepted: 2023-10-13 Published Online: 2023-10-14 Printed: 2023-10-15 Ann Clin Anal Med 2023;14(Suppl 3):S419-422
Corresponding Author: Feray Aras, Department of Nuclear Medicine, Faculty of Medicine, Celal Bayar University, Manisa, Turkey.
E-mail: feray_aras@yahoo.com P: +90 532 420 69 63
Corresponding Author ORCID ID: https://orcid.org/0000-0001-5867-5367
This study was approved by the Ethics Committee of Manisa Celal Bayar University Faculty of Medicine (Date: 2023-08-31, No: 20.478.486/ 1968)

Introduction

Nowadays, the frequency of thyroid diseases has increased significantly and even the incidence of thyroid cancer is gradually increasing. Thyroid nodules are quite common in society. While 4-8% of adults have palpable nodules, the prevalence of nodular disease with ultrasound scanning increases to 68%, and is reported to be 50% in autopsy cases [1]. It is extremely important to elucidate the functional status of the detected thyroid nodules and determine whether they are malignant or not. For this purpose, patients' thyroid function tests, USG (ultrasound) findings and scintigraphic findings are investigated. Although thyroid function tests provide information about the functional status of the thyroid gland and nodules in general, they cannot give any clue about the presence of malignancy [2]. Again, although the USG features of a detected nodule raise suspicion about malignancy, no USG finding is both sensitive and specific in showing malignancy. With thyroid ultrasonography, an attempt is made to differentiate between malignant and benign nodules by looking at the size, structure, echogenicity, calcification, halo presence, border arrangement and blood flow characteristics of the thyroid nodules [3].

Fine needle aspiration biopsy (FNAB) is an important method for the diagnosis and surgical decision of neoplastic and non-neoplastic lesions of the thyroid. With FNAB, unnecessary surgery rates and related complications have decreased. FNAB is stated to be easily performed, less invasive and more cost-effective [4]. Ultrasound-guided FNAB has lower non-diagnostic content and false negative rates [5]. The approach to the diagnosis, follow-up and treatment of thyroid nodules was determined in the guide published by the American Thyroid Association (ATA). Thyroid ultrasonography should be performed on every patient suspected of having a thyroid nodule. If the diameter of the thyroid nodule is greater than 1 cm, fine needle aspiration biopsy (FNAB) is recommended regardless of the features on ultrasonography [6].

One of the examinations performed to determine the malignant potential of thyroid nodules is thyroid scintigraphy. Uptake rates and washout levels in thyroid scintigraphy performed with Tc-99m MIBI (Methoxyisobutylisonitrile) can be guiding in terms of the presence of malignancy in nodules [1]. Radionuclide thyroid scintigraphy (RTS) with technetium-99m pertechnetate and power Doppler ultrasonography (PDUS) can be used to evaluate the vascularization of thyroid nodules. RTA has been used to increase the diagnostic accuracy of static thyroid screening [7]. Today, regardless of the sensitivity of the USG devices or the experience of the doctor performing the biopsy, FNAB is an invasive procedure and has some undesirable side effects. In this study, we want to contribute to determining the malignancy potential of the nodule by using a non-invasive method of analyzing thyroid scintigraphy images. However, in our study, we want to investigate whether there is a correlation between the blood supply of the nodules and the malignancy potential, using the data obtained from the scintigraphy images, where thyroid scintigraphy was performed in our department to determine the nodule activity in patients diagnosed with solitary and/or multinodular goiter, and images of the blood supply phase were also taken under the camera.

Material and Methods

The study was initiated after the approval of Manisa Celal Bayar University Faculty of Medicine Health Sciences Ethics Committee (Approval date and No: 31/08/2023 / 20.478.486/ 1968). Our research is a retrospective study. Between January 2012 and January 2023, 48 patients who had radionuclide thyroid scintigraphy (RTS) examinations, had thyroid nodules and were diagnosed with benign/ malign thyroid tumors by surgical resection were included in the study.

The scintigraphic images available in the archive were analyzed. No out-of-routine transactions were performed.

Time-activity curves obtained from ROI (region of interest) drawings on blood supply and activity retention images of the thyroid gland and nodules of patients who were referred to the clinic for Radionuclide Thyroid scintigraphy (RTS) and had substance injection under camera were evaluated.

The compatibility of the data obtained from the scintigraphy images performed on patients with thyroid nodules with the clinical results was compared.

Radionuclide Thyroid scintigraphy and power Doppler ultrasonography (PDUS)

Taking the patients' thyroid area as the area of interest, dynamic imaging was achieved by giving 1.33 zoom under a dual-headed gamma camera fitted with a parallel-hole low-energy general-purpose collimator (Infinia, GE medical systems, Tirat, Hacermel) and by injecting 185 Mβq Tc99mpertechnetate intravenously. Then, anterior and oblique static images were obtained with the pinhole collimator. A time-activity curve was drawn from the dynamic images. Retention rate (RR) was calculated using these curves and static anterior image counts. RR was found by drawing a total of 75 nodules of 48 patients. Power Doppler ultrasonography (PDUS) was performed on each patient at the same time and central and peripheral resistive index (RI) were measured. Nodule vascularization pattern was classified in PDUS.

Statistical analysis

Statistical analyzes were performed using the SPSS 27.0 (Statistical Package for the Social Sciences, USA) program. Descriptive statistics were presented as mean ± standard deviation for those with normal distribution, as the median value in the min-max range for those who were not normally distributed, and as numbers and percentages for those with nominal distribution. In the study, the presence of differences between groups (benign, malignant) in terms of continuous variables was evaluated with Student's t Test and Mann-Whitney U Test in independent Groups. Pearson's chi-square test and Fisher's Exact test were used in the analysis of nominal variables. For $p<0.05$, the results were considered statistically significant.

Ethical Approval

Ethics Committee approval for the study was obtained.

Results

The mean age of the patients was 54.12 ± 13.41 years. While 40 patients had a fine needle aspiration biopsy (FNAB), 8 patients did not have an FNAB. Of the 64 nodules in 40 patients who underwent FNAB, 20 were detected as nondiagnostic, 38

as benign cytology (BC), and 6 as malignant cytology (MC) (Table 1). In the time activity curve obtained from RTA, it was determined that the probability of malignancy was high in nodules that were hyper-vascular and showed rapid clearance. While the average RR of nodules in BC was 0.41±0.70, it was calculated as 0.43±0.23 in MC. The average central RI in nodules in BS was 0.39±0.12, while in MC it was 0.30±0.63. The average peripheral RI value was calculated as 0.60±0.45 in BC and 0.62±0.29 in MC (Table 2). Although our number of malignant cytology nodules was quite low, there was a statistically significant positive correlation between the malignant cytology RR value and the malignant cytology peripheral RI value (p = 0.003, r = 0.043). There was a significant positive correlation between the BC central RI value and the BC RR value (p = 0.012, r = 0.054) (Table 3).

Table 1. Socio-demographic and fine needle aspiration biopsy (IIAB) findings of the patients

	N, %, mean±SD
Gender	
Female	30 (62,5%)
Male	18 (37,5%)
Age (Year)	54,12 ± 13,41
IIAB	
Nondiagnostic (ND)	20 (31,25%)
Benign cytology (BC)	38 (59,37%)
Malignant cytology (MC)	6 (9,37%)

Table 2. Comparison of PDUS parameters (PRI and SRI) with RTS scintigraphy parameters (RR) in benign and malignant cytology

	Benign cytology	Malignant cytology	P value
Retention rate (RR)	0,41±0,70	0,43±0,23	0.092
Central resistive index (SRI)	0,39±0,12	0,30±0,63	0.001
Peripheral resistive index (PRI)	0,60±0,45	0,62±0,29	0.243

Table 3. Correlation of PDUS parameters (PRI and SRI) with RTS scintigraphy parameter (RR) in malignant cytology and benign cytology

Malignant cytology	Retention rate (RR)
Peripheral resistive index (PRI)	P = 0.003; r = 0,041
Benign cytology	
Central resistive index (SRI)	p = 0,012; r = 0,031

Discussion

In our study, we evaluated the role of dynamic scintigraphic imaging with Tc-99m MIBI and PDUS parameters in differentiating malignant and benign thyroid nodules. Thyroid nodules are one of the common diseases of the thyroid. It is known that the frequency of nodules, which constitute the most common disease group of the thyroid gland, increases with age, and the sonographic frequency is over 50% over the age of 50 [3, 6, 7]. In the etiology of thyroid nodules, the causes include malignant and benign pathologies. Malignant tumors of the thyroid constitute 1% of all cancers [5]. The current diagnostic algorithm includes laboratory tests, thyroid US, thyroid scintigraphy, and, if necessary, US-guided fine needle aspiration cytology [6]. When a thyroid nodule is detected, the primary approach is to exclude the risk of cancer, which exists in approximately 5% of nodules, and to reduce unnecessary surgery [2]. USG, the most commonly used imaging method in the diagnosis of thyroid diseases, gives rough information about the malignancy risk of nodules. In our study, the number of women with nodules was higher in terms of gender. The average age of the patients was consistent with the literature. Compared to the cancer risk rate in the literature (5%), the cancer risk as a result of FNAB in our study was 9.37%.

Today, FNAB is considered the most appropriate and reliable method for distinguishing benign from malignant thyroid nodules. However, cytology results are reported as ambiguous in a non-negligible number of Patients [4]. Additionally, some cytology results are insufficient for diagnosis. Despite repeated biopsies, diagnosis cannot be made in approximately 7% of nodules, and the malignancy rate in these nodules is around 20% and is higher than normal. The false negative rate of biopsies is around 1.7% [5]. Therefore, a second biopsy may be required when changing USG characteristics of the nodule and/or significant growth are detected during follow-up. In our study, 31.25% of the nodules were found to be undiagnosed according to the FNAB result. This rate was high compared to the literature.

Due to the limitations of the methods used to detect thyroid cancer outlined above, research on new noninvasive methods continues. Tc-99m MIBI scintigraphy, which is used in the evaluation of malignancies such as lung, breast, brain, lymphoma, bone and soft tissue, has also been investigated for the prediction of thyroid cancers. In addition to the heterogeneity in the inclusion criteria and methods used in the reported studies, there are also significant differences in the diagnostic performance values [8]. In general, Tc-99m MIBI scintigraphy seems to be a cost-effective method that is thought to contribute to the evaluation of thyroid nodules. However, there is no recommendation in current guidelines for the use of Tc-99m MIBI scintigraphy to predict the cancer risk of thyroid nodules [9, 10]. In a meta-analysis of 21 studies reported by Treglia G et al, the pooled sensitivity and specificity of Tc-99m MIBI scanning in detecting malignant thyroid nodules were 85.1% and 45.7% per lesion, respectively, regardless of the final results of previous technetium pertechnetate or iodine-123 screening [11].

The relationship between the histopathological structure of the nodule and vascular resistance was found to be significant in most studies. Central and peripheral RI values measured by

power Doppler USG are very valuable because they are not affected by nodule size [12]. Although arteries, arterioles and capillaries create vascular resistance, arterioles are largely responsible. Resistivity index is a popular parameter to evaluate arteries [13]. Since the growth of the tumor depends on its nutrition and the formation of blood vessels, neovascularization and angiogenesis are observed in malignant nodules. End-diastolic flow velocities decrease due to fistulas formed due to abnormal vascularization. Accordingly, the resistive Index (RI) values are expected to increase [14]. Bakhshaee et al [15] found RI values to be significantly higher in malignant nodules. The average RI value in malignant nodules was determined to be 0.72 ± 0.13. Chammas et al [16] determined the average RI values to be 0.74 ± 0.12 and emphasized that RI values are high in case of malignancy. In their study on the power Doppler properties of thyroid nodules, Holden found the average RI values to be 0.57 in colloid nodules, 0.66 in adenomas, and 0.76 in carcinomas, and emphasized that they were higher in malignant nodules [17]. In their study on follicular carcinomas of the thyroid, Miyakawa et al [18] compared follicular adenomas with follicular carcinomas and calculated the average RI value in follicular adenomas as 0.60 ± 0.2, and the average RI value in follicular carcinomas as 0.80 ± 0.1. In our study, RI values of malignant nodules were found to be high, consistent with the literature. Unlike the literature, in our study, malignant nodules were found to have numerically higher peripheral RI (0.62±0.29) and lower central RI (0.30±0.63) values than benign nodules (mostly follicular adenoma). In addition, although our number of MC was quite small, there was a statistically significant positive correlation between the RR value and peripheral RI value in MC. There was also a statistically significant positive correlation between central RI and RR in BC.

Conclusion

In conclusion, the results of our study will be important in the differential diagnosis of benign and malignant thyroid nodules in non-diagnostic or insufficient FNAB cases. The data obtained from this study can also be used in the follow-up of patients with cytologically 'high' risk thyroid nodules such as Hurtle cell adenomas and follicular adenomas. According to the results of our study, we think that when a nodule with a high probability of being benign is detected, follow-up will be recommended, whereas when a nodule with high malignant potential is detected, FNAB and subsequent surgical intervention will be performed immediately and the patient will be delivered to the most clinically effective result. In this way, a possible malignant process will be detected at an early stage and the disease will be treated surgically before it progresses, thus preventing unnecessary procedures and additional costs for the patient. In addition, examinations with tumor screening agents can help determine the preoperative stage of thyroid carcinoma patients with locally advanced disease and accurately determine the extent of the disease and therefore the surgical treatment to be applied.

Scientific Responsibility Statement

The authors declare that they are responsible for the article's scientific content including study design, data collection, analysis and interpretation, writing, some of the main line, or all of the preparation and scientific review of the contents and approval of the final version of the article.

Animal and Human Rights Statement

All procedures performed in this study were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

Funding: *None*

Conflict of Interest

The authors declare that there is no conflict of interest.

References

1. Alexander EK, Cibas ES. Diagnosis of thyroid nodules. Lancet Diabetes Endocrinol. 2022; 10(7): 533-9.

2. Wong R, Farrell SG, Grossmann M. Thyroid nodules: diagnosis and management. Med J Aust. 2018; 209(2): 92-8.

3. Alexander EK, Doherty GM, Barletta JA. Management of thyroid nodules. Lancet Diabetes Endocrinol. 2022; 10(7): 540-8.

4. Liu T, Tilak M, Awad S, Lakoff J. A Literature Review of Factors Associated With Pain From Fine Needle Aspiration Biopsy of Thyroid Nodules. Endocr Pract. 2022; 28(6): 628-36.

5. Yim Y, Baek JH. Core needle biopsy in the management of thyroid nodules with an indeterminate fine-needle aspiration report. Gland Surg. 2019; 8(2): S77-S85.

6. Mistry R, Hillyar C, Nibber A, Sooriyamoorthy T, Kumar N. Ultrasound Classification of Thyroid Nodules: A Systematic Review. Cureus. 2020; 12(3): e7239.

7. Abdelhamed HM, Abdo Soliman MS, Mahmoud AA, Mohamed R, Ali IM, Abdelhai SF. The utility of technetium-99m pertechnetate thyroid scintigraphy assessing thyroid/salivary ratio as an alternative to thyroid uptake percentage in evaluation of thyroid function, with establishing normal reference values of both parameters: single Egyptian center study. Nucl Med Commun. 2022; 43(12): 1181-7.

8. Gladic Nenadic V, Sisko Markos I, Punda M, Blazekovic I, Franceschi M, Frobe A, et al. (99m)Tc-MIBI Spect/CT Scintigraphy And Ultrasound Of The Anterior Neck Region In Diagnosing Parathyroid Gland Pathology In Patients With Thyroid Nodules. Acta Clin Croat. 2022; 60(3): 423-8.

9. Schenke SA, Campenni A, Tuncel M, Bottoni G, Sager S, Bogovic Crncic T, et al. Diagnostic Performance of (99m)Tc-Methoxy-Isobuty-Isonitrile (MIBI) for Risk Stratification of Hypofunctioning Thyroid Nodules: A European Multicenter Study. Diagnostics (Basel). 2022; 12(6).

10. Schenke SA, Klett R, Wagner PR, Mott S, Zimny M, Feek U, et al. Characteristics of different histological subtypes of thyroid nodules classified with 99mTc-methoxy-isobutyl-isonitrile imaging and Thyroid Imaging Reporting And Data System. Nucl Med Commun. 2021; 42(1): 73-80.

11. Treglia G, Caldarella C, Saggiorato E, Ceriani L, Orlandi F, Salvatori M, et al. Diagnostic performance of (99m)Tc-MIBI scan in predicting the malignancy of thyroid nodules: a meta-analysis. Endocrine. 2013; 44(1): 70-8.

12. Moraes PHM, Takahashi MS, Vanderlei FAB, Schelini MV, Chacon DA, Tavares MR, et al. Multiparametric Ultrasound Evaluation of the Thyroid: Elastography as a Key Tool in the Risk Prediction of Undetermined Nodules (Bethesda III and IV)-Histopathological Correlation. Ultrasound Med Biol. 2021; 47(5): 1219-26.

13. Fathy MM, Megali HI, Abd El-Hafeez W. Vascular pattern and spectral parameters of Doppler ultrasound in differentiation between malignant and benign thyroid nodules. Journal of Current Medical Research Practice. 2021; 6(1): 82.

14. Assem Hussein M, Abdel Hamid A, M Abdel Samie R, Hussein E, Sadik Elsawy S. Duplex Hemodynamic Parameters of Both Superior and Inferior Thyroid Arteries in Evaluation of Thyroid Hyperfunction Disorders. International Journal of General Medicine. 2022: 7131-44.

15. Bakhshaee M, Davoudi Y, Mehrabi M, Layegh P, Mirsadaee S, Rad MP, et al. Vascular pattern and spectral parameters of power Doppler ultrasound as predictors of malignancy risk in thyroid nodules. Laryngoscope. 2008; 118(12): 2182-6.

16. Chammas MC, Gerhard R, de Oliveira IR, Widman A, de Barros N, Durazzo M, et al. Thyroid nodules: evaluation with power Doppler and duplex Doppler ultrasound. Otolaryngol Head Neck Surg. 2005; 132(6): 874-82.

17. Holden A. The role of colour and duplex Doppler ultrasound in the assessment of thyroid nodules. Australas Radiol. 1995; 39(4): 343-9.

18. Miyakawa M, Onoda N, Etoh M, Fukuda I, Takano K, Okamoto T, et al. Diagnosis of thyroid follicular carcinoma by the vascular pattern and velocimetric parameters using high resolution pulsed and power Doppler ultrasonography. Endocr J. 2005; 52(2): 207-12.

How to cite this article:

Feray Aras. *The role and importance of dynamic thyroid scintigraphy in clinical practice. Ann Clin Anal Med 2023;14(Suppl 3):S419-422*

This study was approved by the Ethics Committee of Manisa Celal Bayar University Faculty of Medicine (Date: 2023-08-31, No: 20.478.486/ 1968)